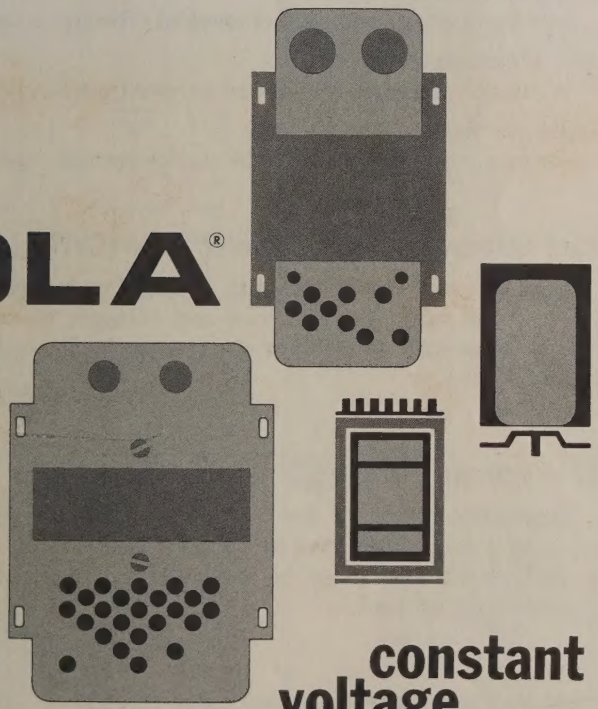
ADAPTOR KIT - 2-3 WKS

OPERATING AND SERVICE MANUAL

SOLA®



constant voltage

TRANSFORMERS

SOLA ELECTRIC

DIVISION OF SOLA BASIC INDUSTRIES

1717 BUSSE Rd. ELK GROVE VILLAGE, ILLINOIS 60007
PHONE 312-439-2800 TELEX 25-3395

This operating and service manual has been carefully prepared to insure that your SOLA Constant Voltage Transformer can be operated and serviced with minimal effort and involvement. For your convenience we have condensed this manual and have established a code system to distinguish between information applicable to either CVN, CVS, CVE, or CVF. The code system is as follows:

N Indicates material applies to
constant voltage normal-harmonic type transformer

S Indicates material applies to
constant voltage standard sinusoidal type transformer

E Indicates material applies to
constant voltage plate-filament service transformer

F Indicates material applies to
constant voltage filament type service transformer

N Constant Voltage Normal-Harmonic Type (CVN)

Regulation ±1% or less with a total input variation of ±15% . . . wide range of capacities and voltages as well as housing, mounting, and connection features to facilitate use as product component.

S Constant Voltage Standard Sinusoidal Type (CVS)

Regulation ±1% or less with a total line variation of ±15% . . . and in addition has less than 3% total rms harmonic content at full load. May be used without regard for wave-shape sensitivity of load.

E Constant Voltage Plate-Filament Type (CVE)

A single, compact source of plate and filament supply voltages . . . regulated to within ±3% or less with line voltage variations of 100-130 volts.

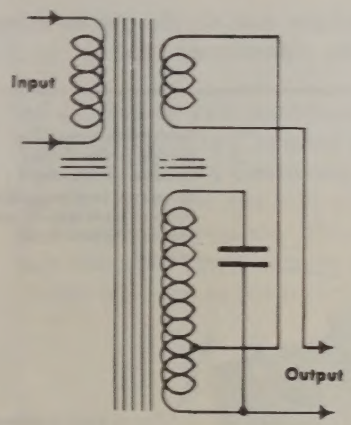
F Constant Voltage Filament Type (CVF)

A compact, chassis-mounted source of ±1%-regulated filament voltages that extends life, improves performance of 6.3 volt electron tubes. Current-limiting characteristic protects tube filaments against cold inrush currents, when transformer capacity is matched to loading.

TOTAL REGULATION from SOLA

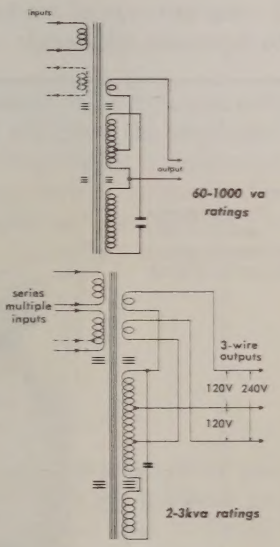
SCHEMATICS

N

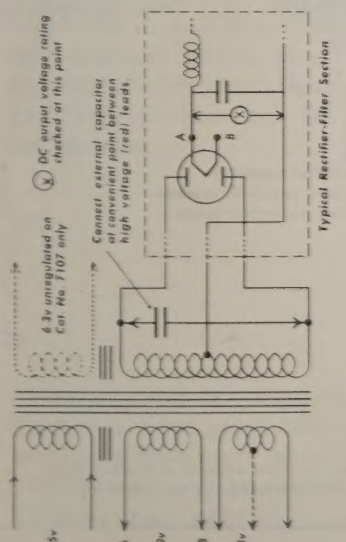


A—"Line Voltage" Types

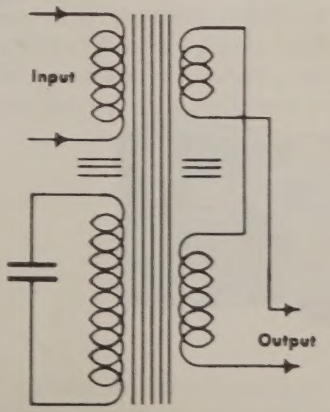
S



E



F

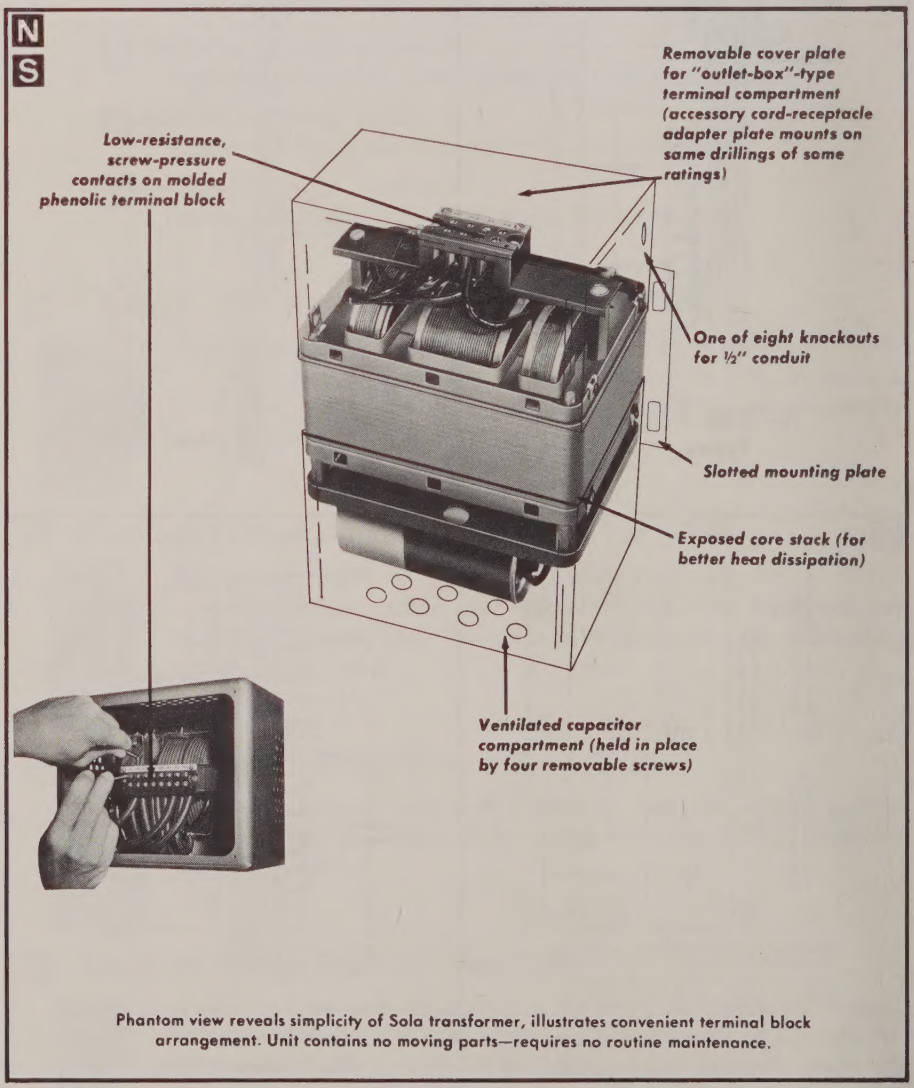


B—"Filament" or "Low-Voltage" Types

TOTAL REGULATION from SOLA

MECHANICAL ASSEMBLY

The following are *typical* mechanical assemblies and should not be misconstrued to represent all models of any specific transformer type.


N
S
Removable cover plate for "outlet-box"-type terminal compartment (accessory cord-receptacle adapter plate mounts on same drillings of some ratings)
Low-resistance, screw-pressure contacts on molded phenolic terminal block
One of eight knockouts for ½" conduit
Slotted mounting plate
Exposed core stack (for better heat dissipation)
Ventilated capacitor compartment (held in place by four removable screws)

Phantom view reveals simplicity of Sola transformer, illustrates convenient terminal block arrangement. Unit contains no moving parts—requires no routine maintenance.

INSTALLATION

Position

N S All stock sizes with end housings are intended to be mounted with name-plate right side up. On most ratings, this will place the ventilated capacitor compartment downward, thus providing cooler operation of capacitor(s). However, any unit will give satisfactory performance if mounted in a horizontal position. The separate capacitor unit furnished with certain filament voltage ratings may be mounted in any convenient location, preferably close to the transformer assembly.

E F Units of this type are intended for mounting with name-plate upright, on the horizontal surface of a chassis structure, with flexible leads projecting downward through suitable holes. The capacitor unit IS ESSENTIAL for proper operation, but is furnished separately, so it can be mounted in any convenient spot near the transformer component. It, too, is intended for mounting with terminals projecting downward through suitable holes in a chassis surface; and mounting brackets furnished with each capacitor are designed for such mounting. However, the transformer and capacitor will work equally well in any position or mounting method; and the capacitor does not have to be immediately adjacent to the transformer.

Space

N S E F All ratings depend on natural draft air circulation for adequate cooling. They should not be mounted in confined or enclosed spaces unless special provisions have been made for ventilation. Sola's Engineering Department stands ready to consult on doubtful cases. (See note on "Operating Temperatures" page 13.)

TOTAL REGULATION from SOLA

CONNECTIONS

N S

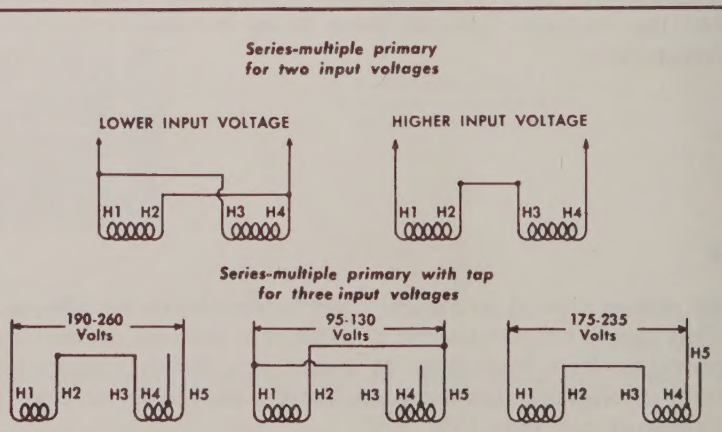
On 60 va rating, screwtype lugs in outlet box are clearly marked "input" and "output", and no connection diagram is necessary. Units rated 120-7500 va are provided with multiple inputs and/or output connections for any one of two or three line voltages, and some have provision for three-wire output. With all such ratings, a connection diagram is attached to inside lid of outlet box cover, or inserted in outlet box. However, the available alternate connections are shown below for convenient reference.

For certain smaller ratings, an accessory adapter plate – carrying an input cord and output receptacle, or jacks, is available at small additional cost. Simple directions for screwdriver conversion are furnished with the adapter kit.

It is desirable to have a switch in the input circuit for turning off power when the unit is not in use. While all CV Transformers are designed for continuous duty, they draw appreciable current whether serving load or not. (See "Input Characteristics".)

Multiple Input and Output Connections

N S

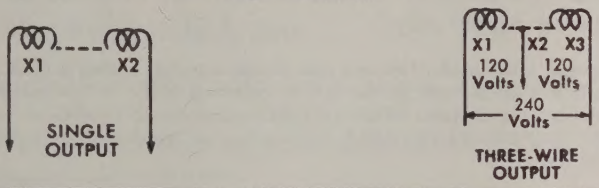


TOTAL REGULATION from SOLA

CONNECTIONS (Continued)

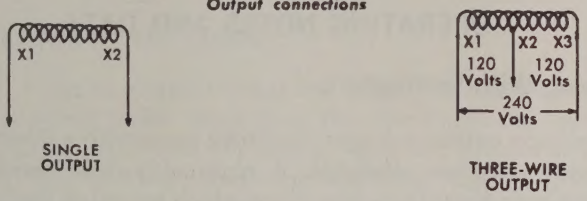
N

Output connections

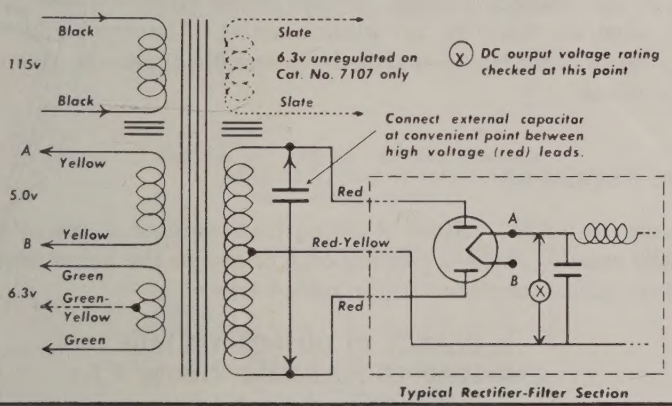


S

Output connections

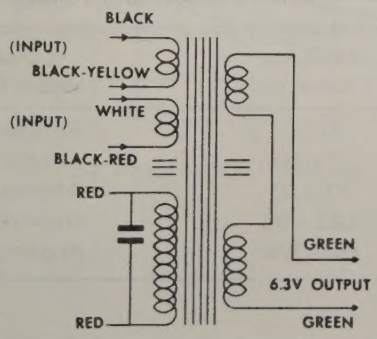


E



Typical Rectifier-Filter Section

F



TOTAL REGULATION from SOLA

POWER SUPPLY

N S E F

All stock sizes listed in current bulletins are intended for nominal 60-Hertz power supply only.

Current semi-standard designs with catalog numbers ending in 5XX, 6XX, 7XX, and certain older designs in "50 series" (showing letter "B" in catalog number), are designed for 50-Hertz SERVICE ONLY. Units for 50 or 60-Hertz service only ARE NOT INTERCHANGEABLE, nor can they be "readjusted" or "rebuilt" for the other frequency.

OPERATING NOTES AND DATA

Checking With Voltmeters

All checks on output voltages should be made with a dynamometer-type voltmeter whenever available. A reasonably-close check can also be obtained with those iron-vane types which are rated for "25-500 Hertz" or broader frequency range. Thermocouple types will also give reasonably accurate readings. A certain amount of harmonics in the output may cause other types—particularly rectifier types—to give inaccurate indications.

Load Regulation

N S

Changes in output voltage resulting from changes in resistive loads are usually small – running one per cent or less in the larger units. Typical average values are shown in the table below.

CHANGE IN OUTPUT VOLTAGE
NO-LOAD TO FULL-LOAD (100% P.F.)
With Nominal Input Voltage

Transformer Cap. in VA	% Change in Output Voltage
0-10	Approx. 6%
11-30	Approx. 2%
31-120	Approx. 3%
121-150	Approx. 2%
151-Over	Approx. 1%

OPERATING NOTES AND DATA (con't)

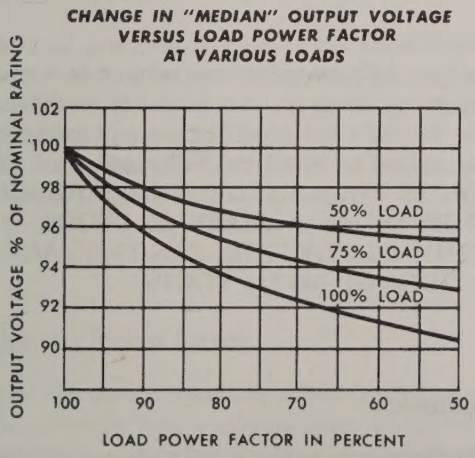
Three-Wire Regulating Action

N S

On those units provided with 3-wire output, the standard regulating action of ±1% or better may be secured from the 240-volt terminals alone, from either 120-volt leg alone, combination 240 and 120-volt loads, or unbalanced 120-volt loads.

Effect of Load Power Factor

"Median" value of output voltage will vary from nameplate rating if the load has a power factor other than that for which the transformer was designed. Load regulation will also be relatively greater as the inductive load power factor is decreased (see following chart of average values). However, the resulting median values of output voltage will be regulated against supply line changes at any reasonable load or load power factor.



OPERATING NOTES AND DATA (con't)

Basis for Nominal Voltage Ratings

Nominal DC values for high voltage outputs are based on conventional power transformer practice. Factory test and inspection (as well as guarantee adjustments) are based on full rated load from rectifier-filter circuits as follows:

Transformer Catalog Number	Full-Wave Rectifier Tube Number	Capacity Input Filter—1st Cap. Rating
7104	5Y3GT	40 mfd.
7106	5Y3GT	40 mfd.
7107	5U4GA-GB	40 mfd.

DC output voltage from conventional choke input filter sections may average about 50 volts less than nameplate values. Other rectifier tubes or unconventional filter constants are likely to produce other minor variations in nominal values.

All nominal output voltage values are subject to a manufacturing tolerance of plus-or-minus three per cent from values shown on nameplate. In addition, there may be a very small amount of load regulation producing slightly higher values at less than full rated load. HOWEVER, ANY NOMINAL OR MIDDLE VALUE WHICH RESULTS FROM ANY COMBINATION OF ALL THESE FACTORS WILL BE REGULATED WITHIN ±3% OF ITSELF IN THE FACE OF LINE VOLTAGE VARIATIONS OF 100-130 VOLTS.

Effect of Frequency

Changes in the frequency of the supply voltage will be directly reflected in the output voltage. A change of about 1.8% in output voltage will occur for every 1% change in input frequency, and in the same direction as the frequency change.

OPERATING NOTES AND DATA (con't)

Response Time

An important advantage of the Sola principle of static magnetic regulation is its exceedingly fast response time, compared with other types of AC regulators. Transient changes in supply voltage are usually corrected by a Sola within 1½ cycles or less; the output voltage will not fluctuate more than a few per cent, even during this interval.

Input Characteristics

Since the Sola CV Transformer includes a resonant circuit which is energized whether it is serving load or not the input current at no load or light load may run 50% or more of the full load primary current. (As a result, the temperature of the unit may rise to substantially full-load level, even at light or no load.) Input power factor will average 90-100% at full load, but may drop to about 75% at half load and 25% at no load. In any case it is always leading.

Current Limitation

When the load is increased beyond the transformer's rated value, a point is reached where the output voltage suddenly collapses and will not regain its normal value until the load is partially released. Under direct short circuit, the load current is limited to approximately 150-200% of the rated full load value, the input watts to less than 10% of normal. A constant voltage transformer will protect both itself and its load against damage from excessive fault currents. Fusing of load circuits is not necessary.

Operation on Motor Loads

Because of the current-limiting effect described above, special attention should be given to motor applications. In general, the CV transformer must have a load rating nearly equal to the maximum power drawn during the starting cycle. This may run from two to eight times the normal (running) rating of the motor. In doubtful cases, it is advisable to measure the actual starting current.

OPERATING NOTES AND DATA (con't)

External Magnetic Field

N S E F

In almost all applications this effect may be disregarded. On critical applications, care should be exercised in orientation of core with respect to critical circuits, in order to minimize the effect of field. Special units may be designed with shielding to reduce the effect of stray magnetic field.

In certain rare cases in which the transformer is connected to, or mounted near, high-gain audio-frequency circuits, special attention may need to be given to adequate physical spacing and/or orientation of the small, residual external field so as to avoid interaction with the audio circuits. Sola's Engineering Department may be able to offer helpful suggestions on such problems.

Output Wave Shape

N S

The operating principle of the Normal-Harmonic Type CVN Transformer is such that the harmonic content of the output voltage wave is relatively small, even at the extremes of the operating range. The amount of harmonic present in the output wave varies with both input voltage and load. The table below shows a typical harmonic analysis under several conditions of input and load.

On applications where harmonics are a disadvantage, it is desirable to select Type CVS, which includes a harmonic-neutralizing circuit.

N

CVN TYPICAL HARMONIC ANALYSIS

		Input Voltage		
		95	115	125
Full Load	3rd	13.0	21.0	29.0
	5th	4.9	8.3	11.0
	7th	2.0	4.1	5.6
75% Load	3rd	19.0	24.0	29.0
	5th	7.6	11.0	13.0
	7th	3.8	5.0	6.8
50% Load	3rd	23.5	26.0	29.5
	5th	10.0	13.0	14.0
	7th	4.8	6.6	8.0

OPERATING NOTES AND DATA (con't)

CVS TYPICAL HARMONIC ANALYSIS*

S

	Input Volts	Harmonics—% of fundamental				
		3rd	5th	7th	9th	Total
Full Load	115	0.76	1.1	0.5	0	1.42
50% Load	115	0.95	0.62	0.16	1.2	1.66
25% Load	115	1.3	0.55	0.18	1.65	2.17

*On production units, the lowest residual harmonic content will usually occur at full load.

Operating Temperature

N S E F

Standard units are designed to operate in ambient temperatures of minus 10°C to plus 40°C. In operation, a temperature rise will occur whether or not the transformer is serving load. Normally, this rise may fall anywhere in the range of 45°C to 85°C, depending on the type and rating. In any case, the maximum operating temperature at an ambient of 40°C is always within safe operating limits for the class of insulating material used. (Special units can be designed for lower heat rise or wider ambient temperature range.)

Isolation

Since the input and output are separated not only electrically, but also physically by a magnetic shunt, the Sola CV has a stronger isolating effect than a conventional transformer. This may often eliminate the need for "static shields."

Multiple Operation

N S

Two CV transformers of the same rating may be connected with their inputs and outputs in parallel. The regulating action will usually be excellent, although the standard ±1% cannot be guaranteed. Series connection of either input or output is not recommended.

Cascade Operation

For applications requiring extremely close regulation, two constant voltage transformers may be operated in "cascade" provided the first, or "driving" unit, is of the Standard Sinusoidal type.

OPERATING NOTES AND DATA (con't)

Cascade Operation (con't)

N S

The output of the combination will show little or no detectable change arising from supply line variations of up to ±15%. However, the combined units will still be frequency sensitive (as discussed under an adjacent heading). Since even good power systems may often vary in frequency by 0.1% or more, the output of a Sola cascade combination may vary by up to 0.25% from this cause alone. In actual practice, then, a cascade combination is highly recommended for special applications requiring regulation in the general region of ±0.25%. If the tandem setup is to be operated at near full rating, then the Type CVS "driver" unit should be one standard size larger than the driven unit, in order to overcome the losses in the latter.

Use With Rectifier Loads

N S

The ratio of crest to rms values is approximately 1.3 at rated load, and slightly lower at fractional loads. This factor must be considered when all or a portion of the voltage is rectified. The rectified voltage will now be 10 -15% lower than if connected directly to a sine wave source.

Use on Three-Phase Power Supply

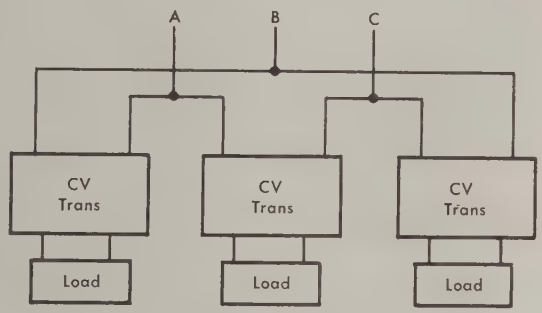
Any three stock units having 230-volt input connections may be connected in delta to a 230-volt, three-phase power supply; those units euipped with primary tap for 175-235 volts may also be connected in delta to a 208-volt supply. (Terminals to be used are identified on the connection diagram located on the inside face of the outlet box cover.)

All stock production, harmonic-free units now have uniform terminal polarity. This eliminates necessity for "phasing out" either input or output connections.

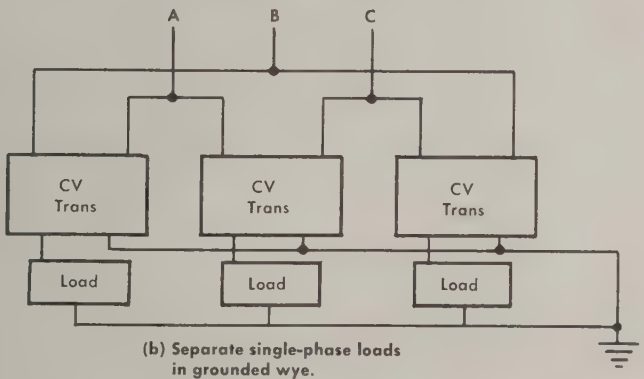
Outputs must serve three, independent, single-phase loads of the same voltage rating (either 120 or 240; not both). Connections should be made in one of two ways shown below:

OPERATING NOTES AND DATA (con't)

N
S



(a) Isolated single-phase loads.



(b) Separate single-phase loads in grounded wye.

Effect of Temperature

N
S
E
F

The output voltage will show a small change as the unit warms up to stable operating temperatures at a constant ambient temperature. This change may be about one or two per cent, depending on the unit's va rating. At a stable operating temperature, the output voltage will change slightly with varying ambient temperature. This shift is approximately one per cent for each 40°C of temperature change.

OPERATING NOTES AND DATA (con't)

Phase Shift

N
S

The phase difference which exists between input voltage and output voltage is in the range of about 120° to 140° at full load. This phase difference varies with the magnitude of the load and, to a lesser extent, with changes in line voltage.

Manufacturing Tolerance

The nominal output voltage of each stock Constant Voltage Transformer (except those with 3-wire output) is adjusted at the factory to within ±1% of rated (nameplate value, with 115, 208, 230 or 460 volts, 60 cps, applied to the input, and with full rated load at 100% power factor applied to the output. This adjustment is made with the unit at substantially the same temperature as room ambient temperature (25°C).

Those stock units with 3-wire output are given a similar adjustment, but to a manufacturing tolerance of plus 2%, minus 0.

SERVICING

No Routine Maintenance Necessary

Since the Sola CV Transformer is a simple rugged device without moving parts or manual adjustments, no "servicing" or "maintenance" is needed in the ordinary sense; and the percentage of possible poor performance or failure is exceedingly low. In any case of apparent poor performance, the user is urged to check the following points immediately:

Checklist on Factors Affecting Performance

A. Nominal Voltage "Too High"

1. The load may be considerably less than full rating. (See note on "Load Regulation" page 8.)
2. The load may have a leading power factor.

B. Nominal Voltage "Too Low"

1. Load power factor may be lagging. (See note on "Load Regulation" page 8.)
2. Unit may be slightly overloaded. (See note on "Current Limitation" page 11.)

C. "Does Not Regulate Closely"

1. Unit may be slightly overloaded. (See note on "Current Limitation" page 11.)
2. Actual line voltage swings may be outside the rated coverage of unit, particularly on low side.
3. On varying loads, a certain amount of load regulation may be mixed with the line voltage regulating action. (See note on "Load Regulation" page 8.)

D. Output Voltage "Very Low" (20-60V)

1. Unsuspected or unplanned overloads of substantial size may occur intermittently (motor-starting currents, solenoid inrush currents, etc.). (See note on "Current Limitation" page 11.)
2. One or more capacitor units in the CV transformer may be defective. (See service note on capacitor checking and replacement, page 19.)

SERVICE (con't)

N
S
E
F

E. "No Output Voltage At All"

1. Check power supply.
2. Check primary fuses if any.
3. Check continuity between input terminals, and also between output terminals.

F. Transformer Operating Temperature

1. These transformers are designed to operate at high flux density, and hence, relatively high temperatures (see operating note page 8). After connection to line for a half hour or so, the exposed core structure may be too hot to touch with bare hand, but this is normal and need give no concern. However, if there is any indication of oil or compound leakage, unit should be returned to factory. (See page 14.)

NOTE: In case transformer is operating but does not appear to have correct output, it is very helpful to apply the following test:

1. Disconnect the working load.
2. Connect a dummy load of lamps, heaters, or other resistive load substantially equal to the full load rating of transformer, directly across its output terminals.
3. Measure the output voltage of the CV using a dynamometer type voltmeter directly across its output terminals.

This test will usually establish whether the apparent poor performance is due to a fault in the CV Transformer or to some peculiarity of the working load. Sola's Sales Engineering Division will then be in far better position to give helpful advice or suggest factory test or service as indicated.

Factory Test and Inspection

If the field test suggested earlier indicated that the CV transformer itself may be faulty, a full report of the difficulty should be sent to the Sola factory at Elk Grove Village, with a request for permission for return. The Elk Grove Village sales office may then suggest further helpful field tests, or authorize return for inspection at once.

SERVICE (con't)

Factory Test and Inspection (con't)

NSEF

Units for factory inspection should be shipped by prepaid transportation direct to the **Sola factory at 1717 Busse Road, Elk Grove Village, Illinois** When the unit has been received, inspected, and tested, you will receive a report on the findings along with a quotation on any recommend repairs falling outside our standard guarantee.

Field Replacement of Capacitors

Capacitors used in all CV transformers are the highest commercial grade available. Each one is given a rigid acceptance test upon receipt. Nevertheless, as with all capacitors, there is a certain small percentage of failure. Sola's guarantee includes free replacement at the factory of any capacitor unit which fails within one year of sale. Older units can be replaced at moderate charge.

Where competent technical help is available, it may be possible to test and identify defective capacitors in the field, and to make field replacement with new units shipped from the factory. In all such cases, factory advice and cooperation should be requested in advance (otherwise Sola cannot be responsible for costs or results.

23-22-125

Guarantee

Sola Constant Voltage Transformers are guaranteed against failure due to faulty materials or workmanship for a period of one year from date of sale. See instructions about adjustments in preceding pages.

SOLA ELECTRIC

DIVISION OF SOLA BASIC INDUSTRIES

1717 BUSSE Rd. ELK GROVE VILLAGE, ILLINOIS 60007
PHONE 312-439-2800 TELEX 25-3395

Litho in U.S.A.

Form 538